

Exploring New Frontiers Together

By DEEPANJALI KAKATI

Talk U.S.-India space links and the first images that come to mind are of Sunita Williams' record breaking voyage on the International Space Station and Kalpana Chawla's tragic flight on the space shuttle *Columbia*. It is because of people like Chawla and Williams, both NASA astronauts of Indian origin, that space has captured the popular imagination in India.

The current buzz, however, is about India's first unmanned moon mission. The *Chandrayaan-1*, carried into space by the Indian Space Research Organisation's (ISRO) Polar Satellite Launch Vehicle, is

to orbit the moon and collect data for at least two years. *Chandrayaan-1* will use 11 scientific instruments—including two from the National Aeronautics and Space Administration (NASA)—to prepare a three-dimensional atlas of the near and far side of the moon. It will also conduct chemical and mineralogical mapping of the entire lunar surface.

This information could help answer questions about "the origin and evolution of the solar system in general and that of the moon in particular," according to the ISRO's moon mission Web site. Future astronauts may use this data map to find

ice and other resources to support human exploration on the moon's surface.

"Both India and the U.S. share important goals and interests in lunar exploration and the experience of *Chandrayaan* has created the working relationships that are the seeds of future cooperation," says Stewart Nozette, principal investigator and chief scientist of the program to develop the Miniature Synthetic Aperture Radar, one of the NASA payloads for the *Chandrayaan-1* mission.

"An analogy is the *Apollo Soyuz* mission in 1975. It opened the door to U.S.-Russian cooperation on the space station



Far right: An enhanced false color scheme shows the diversity of materials across the moon's surface in this composite image.

Right: R.K. Murali of ISRO (second from left), and Chandrayaan-1 Project Director M. Annadurai, (third from left) with the Moon Mineralogy Mapper team at a design review at NASA's Jet Propulsion Laboratory in California. Carle M. Pieters, the team's principal investigator, is holding the Indian flag.



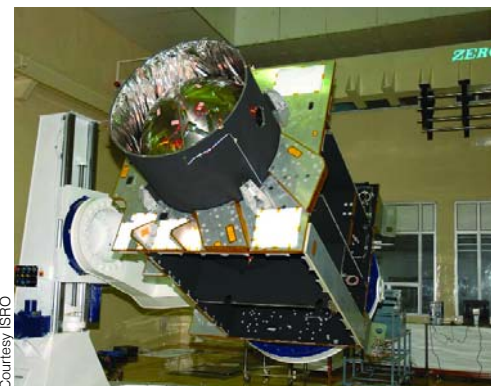


Courtesy NASA

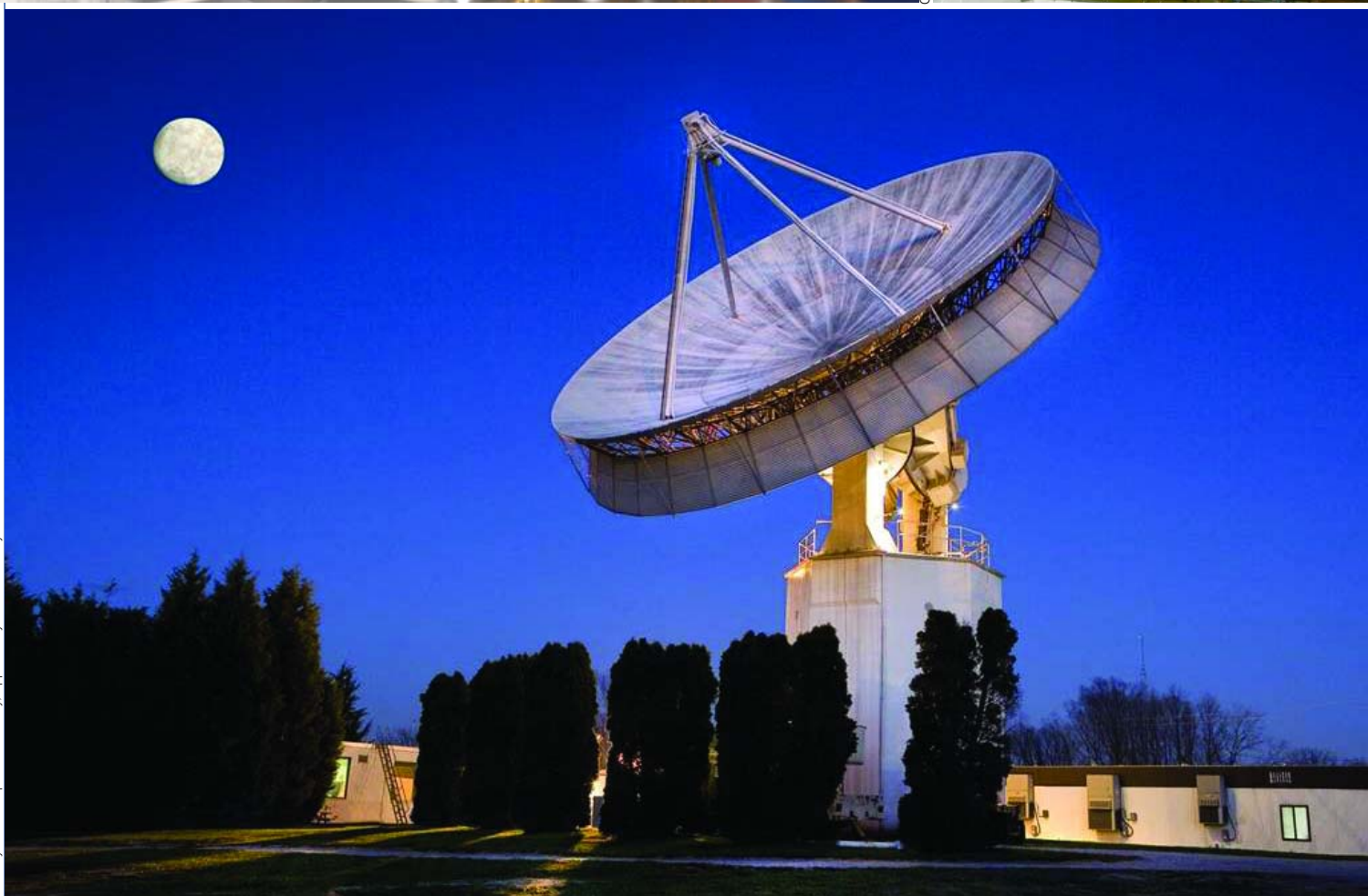
Left: ISRO technicians place the Moon Mineralogy Mapper electronics on a Chandrayaan-1 panel.

Below: The Chandrayaan-1 structure.

Bottom: The ground station at the Applied Physics Laboratory of Johns Hopkins University in Laurel, Maryland, which will track Chandrayaan-1 when it is out of view of ISRO in Bangalore.



Courtesy ISRO



Courtesy Johns Hopkins University, Applied Physics Laboratory

by creating a cadre of people who had experience and relationships, and future cooperation was built upon this base,” adds Nozette, who is also president of the nonprofit Alliance for Competitive Technology and a visiting scientist at the Lunar and Planetary Institute in Texas.

In addition to the miniature radar, NASA plans to send a Moon Mineralogy Mapper aboard *Chandrayaan-1*. Built by NASA’s Jet Propulsion Laboratory in Pasadena, California, and Brown University in Rhode Island, the moon mapper will provide the first map of the entire lunar surface at high resolution.

This “allows us to understand the geologic history of different features and regions on the moon. It is also valuable information for identifying regions of possible resources,” says Carle M. Pieters, professor at Brown University’s department of geological sciences. Pieters is also principal investigator of the team that made the moon mapper.

The mini radar is aimed at finding water ice up to a depth of a few meters in the permanently shadowed regions of the moon’s poles. It was developed by the Applied Physics Laboratory of the Maryland-based Johns Hopkins University and the U.S. Naval Air Warfare Center in China Lake, California.

Nozette, who was deputy project manager and chief scientist of the *Clementine* moon mission of the 1990s, says the ISRO team incorporated many of the lessons learned in the design and execution of *Clementine* in the design of the *Chandrayaan-1* mission.

“*Clementine* was the first mission to...explore the polar environments in detail. It provided the scientific basis for further exploration, and *Chandrayaan-1* is doing an excellent job at addressing a number of the questions which arose following analyses of *Clementine*’s data,” says Nozette.

The agreement to carry these instruments aboard *Chandrayaan-1* was signed by NASA Administrator Michael Griffin and ISRO Chairman G. Madhavan Nair in Bangalore in May 2006. “...During the

Apollo 15 mission...among the special items our astronauts carried with them was the national flag of India. ...The Indian people deserve to be tremendously proud that the next time the Indian flag travels to the moon it will be placed on a very impressive spacecraft, *Chandrayaan-1*,” Griffin said.

A U.S. connection can be traced to the very beginning of the Indian space program, when India’s first sounding rocket, an American *Nike-Apache*, was launched in

direct broadcast of educational programs on agriculture, family planning, health and hygiene to about 2,400 villages in six Indian states where TV sets with dish antennas were distributed. “This, in my mind, was the spark of a revolution in Indian satellite and telecommunication technologies,” says Chakrabarti, who experienced the excitement generated by the experiment as an undergraduate student in Kolkata.

This experiment was the precursor to the multipurpose INSAT (Indian National Satellite) system of the 1980s, which enabled rapid expansion of India’s television, radio, telecommunications and meteorological sectors. India procured all four satellites of the INSAT-1 series from the California-based Ford Aerospace Corporation and three of them were put into orbit by U.S. launch vehicles. ISRO started building its own satellites from the INSAT-2 series onwards.

In the 1970s, India set up a station to receive data from NASA’s Earth Resources Technology Satellite, which was later renamed Landsat. Several joint experimental projects were undertaken using Landsat data and these led to the development of the Indian Remote Sensing Satellite (IRS) System.

U.S.-India cooperation continued in the 1980s with Anuradha, an Indian cosmic ray experiment, conducted aboard Spacelab-3. A series of agreements since the late 1990s carried forward the relationship. In 1997, India’s Departments of Space and Science and Technology signed



(From left) Former U.S. Commerce Undersecretary Kenneth Juster, ISRO Chairman G. Madhavan Nair and U.S. Ambassador David C. Mulford at the 2004 U.S.-India Conference on Space Science, Applications and Commerce in Bangalore.

November 1963, from Thumba in Kerala. A sounding rocket is designed to probe atmospheric conditions. “One has to recognize that with the exception of the first Indian in space, most of India’s ‘firsts’ in space enjoyed a contribution from the U.S.,” says Supriya Chakrabarti, director of the Center for Space Physics at Boston University.

“Indeed, of the 190 suborbital flights conducted from Thumba listed in the *Encyclopedia Astronautica*, [almost] half used U.S. launchers. I think that this is how India’s future space scientists, technologists and engineers cut their teeth,” Chakrabarti adds.

In the mid-1970s, India conducted one of the largest sociological innovations of the time, the Satellite Instructional Television Experiment. NASA allowed use of one of its Application Technology Satellites over the Indian Ocean for a year. This enabled

For more information:

Indian Space Research Organisation

<http://www.isro.org/>

NASA

<http://www.nasa.gov/>

Chandrayaan-1

<http://www.isro.org/chandrayaan/htmls/home.htm>

Clementine moon mission

<http://nssdc.gsfc.nasa.gov/planetary/clementine.html>

Flights from Thumba

<http://astronautix.com/sites/thumba.htm>

a memorandum of understanding with NASA and the Washington, D.C.-based National Oceanic and Atmospheric Administration for joint research in earth and atmospheric sciences.

The United States also has gained from this relationship, says Boston University's Chakrabarti. "The purchases of early satellites and launch services helped the business community. The U.S. has been able to use expert Indian scientists and engineers in its space programs. Their counterparts, who

returned to India, eased the participation of U.S. scientists in Indian programs," he says.

In 2001, Prime Minister Atal Bihari Vajpayee and President George W. Bush agreed that their governments would discuss ways to stimulate civil space cooperation. An important follow-up to this was the U.S.-India Conference on Space Science, Applications and Commerce in Bangalore in 2004.

"Both countries have a strong commitment to using space for peaceful purposes,

not just for the benefit of their own citizens but for the benefit of all humankind. Both countries have a growing interest in commercializing their national space activities. Out of these shared interests can come significantly expanded cooperation," Lee Morin, a NASA astronaut and then U.S. deputy assistant secretary for health, space and science, said at the conference.

It brought together 550 delegates, including about 150 from the United States. A space exhibition was also organ-

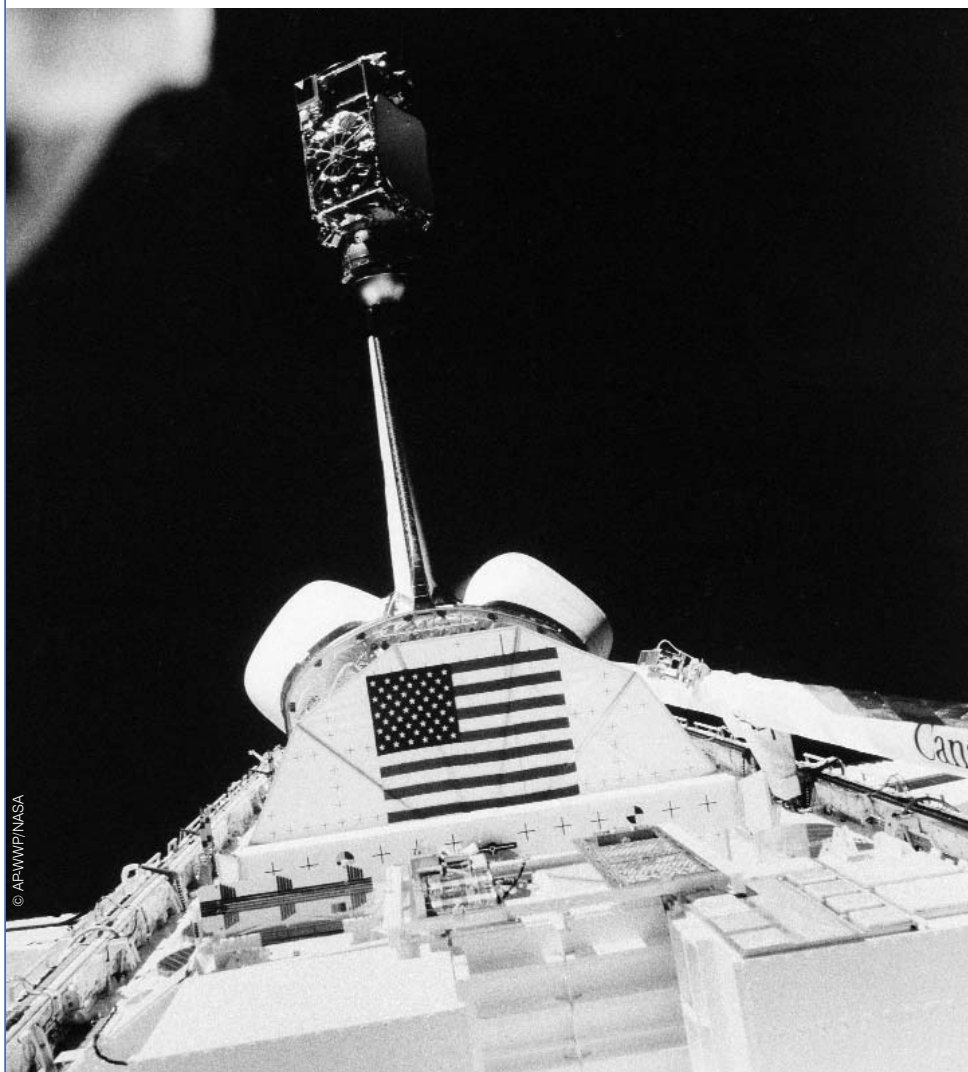
Right: An ISRO technician stands next to a working model of a TV set, designed with NASA's help, for use in the Satellite Instructional Television Experiment.

Far right: The NASA satellite used for the television experiment.

Below: The Indian National Satellite (INSAT) is about to clear the space shuttle Challenger.



Photographs courtesy NASA



ized where 16 American and 21 Indian agencies showcased their space technologies, products and services.

For space enthusiasts, a space mission is the ultimate dream, and two astronauts of Indian origin realized it. Haryana-born Kalpana Chawla's first spaceflight was on the *Columbia* shuttle in 1997. She returned to space again on *Columbia* in January 2003. But she and her six crewmates perished on February 1 as their craft was re-entering Earth's atmosphere.

As flight engineer aboard the International Space Station in 2007, Sunita Williams set an endurance record of 195 days for the longest single spaceflight by a woman. "I am half Indian and I've got, I'm sure, a group of Indian people who are looking forward to seeing this second person of Indian origin flying up in space," she said in a pre-flight interview.

On her visit to India last fall, Williams, whose father was born in Gujarat, was greeted like a rock star. She engaged audiences with her simple message that sometimes what seems like failure is actually an opportunity.

In 2004, Bush and Vajpayee announced the Next Steps in Strategic Partnership, which proposed, among other things, greater engagement on civilian space programs. Bush and Prime Minister Manmohan Singh expanded these commit-



Above: Kalpana Chawla records data for an experiment being conducted aboard the space shuttle Columbia.

Above right: Sunita Williams at work as the expedition flight engineer in the laboratory of the International Space Station in December 2006.



ments in 2005, pledging to build closer ties in space exploration, satellite navigation and launch, and in the commercial space arena through mechanisms such as the U.S.-India Joint Working Group on Civil Space Cooperation.

Comprising representatives of government, academic institutions and industries, this group met for the first time in Bangalore in 2005 and in Washington, D.C. last year. "The placing of two NASA instruments...on *Chandrayaan-1* was helped by negotiation and dialogue that took place in the working group," says Nikhil Khanna, director for aerospace and defense at the U.S.-India Business Council.

The United States and India are working together "on a range of space issues, including the possible deployment on Indian territory of a ground receiving station for data from the U.S. National Polar-Orbiting Operational Environmental Satellite System," says Khanna. "Indian officials are also enlisting U.S. help for satellite-derived products for monitoring floods and wildfires. Cooperation on nat-

ural disaster management and modeling for weather patterns is underway."

NASA and the National Oceanic and Atmospheric Administration also collaborate with India on aerosol monitoring. Aerosols are tiny particles suspended in air, occurring naturally or from human activities like burning of fossil fuels. The National Oceanic and Atmospheric Administration signed an MoU with the Indian Ministry of Earth Sciences in April for cooperation in Earth observations. Several U.S. agencies are working with India to develop and operate a Global Earth Observation System of Systems. It would help mitigate the impact of tsunamis and other disasters, forecast weather months in advance, and more effectively predict climate change, drought and malaria outbreaks.

India participates in the international GLOBE (Global Learning and Observations to Benefit the Environment) program of science education, supported by NASA, the Virginia-based National Science Foundation and the U.S. State Department.

India and the United States also collab-

orate on programs like the International Charter for Space and Major Disasters. The charter is a joint effort to put space technologies at the disposal of rescue authorities in the case of natural disasters or technological ones like oil spills and industrial accidents.

In February 2008, NASA and ISRO signed a framework agreement, replacing the one signed in 1997, to continue to work together in all avenues of space exploration, including manned spaceflight.

One reason why India and the United States will find it useful to work together in space is the superb Indian technical community, says NASA Administrator Griffin. "You have in India wonderful technical schools—scientific, mathematics, engineering; a population that values education in terms of a way to get ahead in life, to improve oneself," he said in an *India Abroad* interview in April.

"I would like to see India, in future years, join us to return people to the moon, among them Indian astronauts—that's what I would like to see. As we are returning to the moon, we will be, I hope, going there in company with the international partners that helped build the space station. I would like to add...India to that partnership."



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